

In-Situ Measurement of Hall Thruster Erosion Using a Fiber Optic Regression Probe

Kurt A. Polzin*

NASA-Marshall Space Flight Center, Huntsville, AL 35812

Valentin Korman

K Sciences, LLC, Huntsville, AL 35801

One potential life-limiting mechanism in a Hall thruster is the erosion of the ceramic material comprising the discharge channel. This is especially true for missions that require long thrusting periods and can be problematic for lifetime qualification, especially when attempting to qualify a thruster by analysis rather than a test lasting the full duration of the mission. In addition to lifetime, several analytical and numerical models include electrode erosion as a mechanism contributing to enhanced transport properties. However, there is still a great deal of dispute over the importance of erosion to transport in Hall thrusters.

The capability to perform an in-situ measurement of discharge channel erosion is useful in addressing both the lifetime and transport concerns. An in-situ measurement would allow for real-time data regarding the erosion rates at different operating points, providing a quick method for empirically anchoring any analysis geared towards lifetime qualification. Erosion rate data over a thruster's operating envelope would also be useful in the modeling of the detailed physics inside the discharge chamber.

There are many different sensors and techniques that have been employed to quantify discharge channel erosion in Hall thrusters. Snapshots of the wear pattern can be obtained at regular shutdown intervals using laser profilometry. Many non-intrusive techniques of varying complexity and sensitivity have been employed to detect the time-varying presence of erosion products in the thruster plume. These include the use quartz crystal microbalances, emission spectroscopy, laser induced fluorescence, and cavity ring-down spectroscopy. While these techniques can provide a very accurate picture of the level of eroded material in the thruster plume, it is more difficult to use them to determine the location from which the material was eroded. Furthermore, none of the methods cited provide a true in-situ measure of erosion at the channel surface while the thruster is in operation (i.e. none yield a continuous channel erosion measurement).

A recent fundamental sensor development effort has led to a novel regression, erosion, and ablation sensor technology (REAST). The REAST sensor allows for measurement of real-time surface erosion rates at a discrete surface location. The sensor was tested using a linear Hall thruster geometry (see Fig. 1), which served as a means of producing plasma erosion of a ceramic discharge chamber. The mass flow rate, discharge voltage, and applied magnetic field strength could be varied, allowing for erosion measurements over a broad thruster operating envelope. Results are presented demonstrating the ability of the REAST sensor to capture not only the insulator erosion rates but also changes in these rates as a function of the discharge parameters.

*Propulsion Research Engineer, Propulsion Research and Technology Applications Branch, Propulsion Systems Department. Senior Member AIAA.

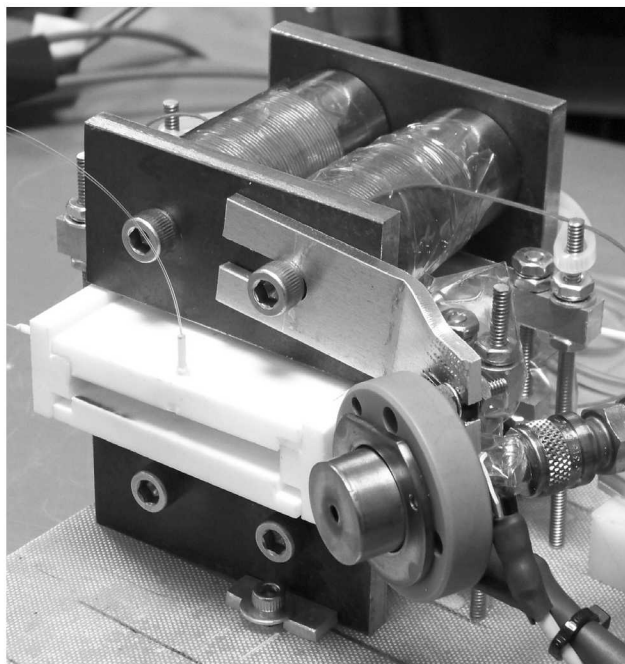


Figure 1. Photograph showing the linear Hall-effect thruster used in this study.